Report

Ultra-low-dose spinal anaesthesia for elective hip arthroplasty in a patient with severe pulmonary hypertension

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Summary

Pulmonary hypertension is a complex chronic cardiopulmonary disease. The condition is an independent risk-factor for peri-operative morbidity and mortality in patients undergoing non-cardiac surgery, with mortality rates of up to 18%. Due to this, patients with pulmonary hypertension are frequently counselled against undergoing all but essential surgery. In this report, we describe the use of ultra-low-dose spinal anaesthetic delivered via intrathecal catheter to allow a patient with severe pulmonary hypertension to safely undergo an elective primary hip arthroplasty for osteoarthritis which was causing intolerable pain. The use of an intrathecal catheter avoided general anaesthesia in a patient who may not have tolerated positive pressure ventilation. The technique also allowed the use of ultra-low doses of spinal anaesthesia, with the option of titrating to effect and duration of surgery. Invasive monitoring allowed proactive management of the haemodynamic effects of neuraxial anaesthesia, specifically the fall in systemic vascular resistance that may be associated with higher doses of spinal anaesthesia. While this report describes a patient with severe pulmonary hypertension, the technique may also be considered for patients with other obstructive cardiac lesions including severe aortic or mitral stenosis.

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Introduction

Pulmonary hypertension is a rare chronic cardiopulmonary disorder that can present significant challenges to the anaesthetist throughout the peri-operative period. The diagnosis of pulmonary hypertension requires a mean pulmonary artery pressure of at least 25 mmHg on right heart catheterisation, but echocardiography is more routinely used. The condition is the result of a heterogeneous group of aetiologies involving respiratory, cardiovascular and haematological systems [1]. Peri-operative management of pulmonary hypertension may be challenging for the anaesthetist due to the precarious balance between right ventricular preload and afterload, which may be altered by both general and regional anaesthesia. Pulmonary hypertension is an independent risk-factor for both peri-operative morbidity and mortality; patients with pulmonary hypertension presenting for non-cardiac surgery have a mortality rate of 1–18% [2]. Pain, acidosis, hypoxaemia and positive pressure ventilation, all of which may be encountered during the peri-operative period, can increase pulmonary vascular resistance and precipitate right ventricular decompensation. Due to these risks, patients with pulmonary hypertension are frequently counselled against

undergoing elective surgery. Neuraxial anaesthesia in patients with this condition may be poorly tolerated and result in cardiovascular collapse due to the unopposed decrease in systemic vascular resistance. However, the use of an intrathecal catheter which allows a titratable low-dose neuraxial anaesthetic combined with invasive cardiac monitoring is a useful technique in such patients. Similar considerations exist for patients with other obstructive cardiac lesions such as severe aortic and mitral stenosis. Prior reports of the management of patients with obstructive lesions presenting for lower limb orthopaedic surgery with neuraxial anaesthesia exist. However, higher doses of spinal anaesthesia are used, and many are limited to the hip fracture repair setting [3].

Report

A 70-year-old woman with severe pulmonary hypertension due to systemic sclerosis presented for elective primary hip arthroplasty for osteoarthritis. Her other comorbidities included atrial fibrillation; ischaemic heart disease; hypothyroidism; and she was on long-term oxygen therapy. She was not prescribed prophylactic anticoagulation at the time of surgery due to previous gastro-intestinal bleed and intracranial haemorrhage when anticoagulated. The medical treatment for her cardiorespiratory disease was optimal. Her pre-operative transthoracic echocardiogram demonstrated a severely enlarged right ventricle with an estimated right ventricular systolic pressure of 70 mmHg, a D-shaped intraventricular septum, severe tricuspid regurgitation and a left ventricular ejection fraction of 55–60%. Despite the risks associated with her procedure, which were explained to her in detail, she wished to proceed with surgery due to the impact of her severe pain on her quality of life.

Following pre-operative assessment and the discussion of the risks and benefits of various anaesthetic techniques, the decision was made to utilise an intrathecal catheter to administer small, incremental doses of local anaesthetic in order to mitigate haemodynamic instability. The patient consented for this anaesthetic technique. Before intrathecal catheter insertion, invasive arterial blood pressure monitoring and central venous access were secured. A Pajunk® Intralong spinal catheter set (Pajunk UK Medical Products Ltd, Newcastle upon Tyne, UK) was used, with a 21-G Sprotte needle and a 25-G catheter. Before insertion, the filter was flushed with isobaric bupivacaine 0.5%. The catheter was inserted at the L3/4 interspace with the patient in the sitting position. Cerebrospinal fluid was obtained at a depth of 7 cm and the catheter was secured at 11 cm. There were no difficulties encountered in catheter placement. No other regional anaesthetic techniques were used.

Noradrenaline and milrinone infusions were connected to the central venous catheter but not commenced. An initial dose of fentanyl 20 μg (0.4 ml) and isobaric bupivacaine 0.5% 2.5 mg (0.5 ml) were injected through the intrathecal catheter with the patient in left lateral position. The patient remained haemodynamically stable, with no requirement for vaso-active drugs. The extent of sensory blockade was tested with ethyl chloride spray, demonstrating loss of cold sensation to the T12 dermatomal level. A further 0.5 mg of bupivacaine 0.5% was administered before skin incision.

The surgery was performed in the left lateral position. There was no intra-operative requirement for vasopressors or inotropes. One further bolus of 0.5 mg of bupivacaine 0.5% was required at skin closure due to mild discomfort. In total, 20 μg (0.4 ml) fentanyl and 3.5 mg (0.7 ml) isobaric bupivacaine 0.5% was used. The total surgical time was 93 min. The intrathecal catheter was removed in the operating theatre at the end of surgery in order to minimise the risk of any complications associated with further intrathecal drug administration and catheter removal. Regular intravenous paracetamol and opioid analgesia were prescribed postoperatively. An intravenous morphine infusion was administered at a rate of 3–5 $mg.h^{-1}$ for the first postoperative night, and subsequently oral oxycodone was prescribed. Prophylactic anticoagulation was commenced on postoperative day one.

The patient had an episode of atrial fibrillation with rapid ventricular response on her first postoperative night, which was treated with intravenous digoxin. Otherwise her postoperative course was uncomplicated. A repeat transthoracic echocardiogram on day three was largely unchanged from pre-operatively. The patient was discharged from hospital to convalescent care on day 15.

Discussion

Pulmonary hypertension is a rare condition, with a prevalence estimated at 15–50 cases per million individuals. It is categorised into five distinct groups based upon the aetiology of the condition. Group 1 (pulmonary arterial hypertension) can be idiopathic or associated with other conditions such as connective tissue disease, congenital heart disease and portal hypertension; group 2 is secondary to left heart disease, either left ventricular dysfunction or valvular disease; group 3 is due to respiratory disease; group 4 is due to chronic thromboembolic disease; and group 5 is a miscellaneous group of aetiologies including sarcoidosis and myeloproliferative disease [1]. It is a chronic cardiopulmonary disorder, characterised by proliferation and fibrosis of small

pulmonary arteries. This results in a progressive increase in pulmonary vascular resistance over time. The resultant right heart failure is the major cause of morbidity and mortality associated with the disease. Transthoracic echocardiogram is the screening investigation of choice when a clinical suspicion of pulmonary hypertension arises, and right heart catheterisation is the gold-standard diagnostic modality. Patients with pulmonary hypertension are at increased risk of peri-operative complications: mortality rates are quoted as 1–18% following non-cardiac surgery and morbidity is reported at 14–42% [2].

Neuraxial anaesthesia is a commonly used anaesthetic technique for elective lower limb surgery. A recent systematic review and meta-analysis recommends neuraxial anaesthesia over general anaesthesia for primary hip and knee arthroplasty [4]. However, it is classically considered relatively contra-indicated in patients with underlying obstructive cardiac lesions including severe aortic or mitral stenosis and pulmonary hypertension [5]. The concern is that the decrease in systemic vascular resistance as a result of sympathetic blockade may cause a devastating fall in venous return and cardiac output. General anaesthesia may be considered a favourable option for some of these patients. However, factors that cause an increase in pulmonary vascular resistance may be encountered during general anaesthesia without due care. These include hypoxia; hypercapnoea; hypothermia; and high ventilatory pressures. Additionally, a decrease in systemic vascular resistance is also encountered with most general anaesthetic agents, risking haemodynamic instability as previously described.

Case reports exist describing low-dose spinal anaesthesia, with or without the use of an intrathecal catheter [3]. Many studies describing effective low-dose spinal anaesthesia for orthopaedic surgery are for patients with hip fracture. Ben-David et al. investigated patients undergoing hip fracture surgery, and demonstrated the efficacy of a bolus intrathecal dose of 4 mg bupivacaine with 20 μg of fentanyl. They also demonstrated a lower requirement for vaso-active medications in this 'minidose' group vs. the standard dose group [6]. More recently, outcomes of a population of over 11,000 patients undergoing hip fracture repair surgery were analysed. Those receiving low-dose spinal anaesthesia (< 1.5 ml bupivacaine 0.5%) were shown to have less hypotension than those receiving higher doses of bupivacaine [7]. Fentanyl is synergistic with local anaesthetics in spinal anaesthesia, resulting in a more efficacious block without the haemodynamic instability that may be associated with higher doses of local anaesthetic. For this reason, intrathecal fentanyl is often utilised in low-dose spinal anaesthesia mixtures.

There is a relative paucity of data regarding the optimal dose of spinal anaesthesia for elective lower limb arthroplasty in the literature. However, a dose-finding study was carried out by Sell et al. in 2004 whereby the minimum effective local anaesthetic dose of levobupivacaine and ropivacaine administered by spinal catheter for hip replacement surgery was investigated [8]. It was found that the levobupivacaine dose effective in 50% of patients was 11.7 mg. Of note, levobupivacaine 0.25% was used, and fentanyl was omitted from the intrathecal anaesthetic. Other literature focuses on the effects of spinal anaesthesia dosing on time to recovery room discharge, as well as whether there is a role for spinal anaesthesia in fast-track joint replacement surgery [9]. The effects of spinal anaesthesia dosing on haemodynamic parameters and outcomes for patients in high-risk groups presenting for elective arthroplasty are not examined.

In general, the elective arthroplasty population is younger and has fewer comorbidities than the hip fracture population. However, healthcare providers are increasingly encountering patients with significant comorbidities presenting for elective surgery. Due to a greater number of these high-risk patients, some of whom will have complex cardiovascular disease, it is useful to consider modification of anaesthetic techniques that may previously have previously been considered contra-indicated in such patients. In recent years, there has been a move away from paternalistic medicine, with a greater focus on patient autonomy. As described in this case, patients may elect to undergo high-risk elective surgery if they believe the potential improvement in quality of life is sufficient to warrant such a risk. As peri-operative clinicians, we should engage in shared decision-making with patients, and inform them of their own specific risk profiles to the best of our ability. We should also be able to provide our highest-risk patients with the safest possible options should they wish to proceed with surgery.

We believe that this is the lowest reported dose of intrathecal local anaesthetic to result in surgical anaesthesia for lower limb arthroplasty. Other case reports exist describing the use of intrathecal catheters for lower limb arthroplasty in high-risk patients. However, higher doses of local anaesthetic are used [10]. The utilisation of an intrathecal catheter provides the anaesthetist with the flexibility of incremental dosing to achieve the correct block height for surgery with concurrent monitoring of any haemodynamic changes. With the ultra-low-dose of intrathecal local anaesthetic used in this case, minimisation of sympathetic blockade and maintenance of haemodynamic stability were achieved. This technique appears to be safe and effective for those patients with obstructive cardiac lesions, including severe pulmonary hypertension, in whom neuraxial anaesthesia is traditionally contra-indicated.

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References

1. Condliffe R, Kiely DG. Critical care management of pulmonary hypertension. *British Journal of Anaesthesia Education* 2017; **17**: 228–34.
2. Pilkington SA, Taboada D, Martinez G. Pulmonary hypertension and its management in patients undergoing non-cardiac surgery. *Anaesthesia* 2015; **70**: 56–70.
3. Collard CD, Eappen S, Lynch EP, Concepcion M. Continuous spinal anesthesia with invasive hemodynamic monitoring for surgical repair of the hip in two patients with severe aortic stenosis. *Anesthesia and Analgesia* 1995; **81**: 195–8.
4. Memtsoudis SG, Cozowicz C, Bekeris J, et al. Anaesthetic care of patients undergoing primary hip and knee arthroplasty: consensus recommendations from the International Consensus on Anaesthesia-Related Outcomes after Surgery group (ICAROS) based on a systematic review and meta-analysis. *British Journal of Anaesthesia* 2019; **123**: 269–87.
5. Morgan P. Spinal anaesthesia in obstetrics. *Canadian Journal of Anesthesia* 1995; **42**: 1145–63.
6. Ben-David B, Frankel R, Arzumonov T, Marchevsky Y, Volpin G. Minidose bupivacaine-fentanyl spinal anesthesia for surgical repair of hip fracture in the aged. *Anesthesiology* 2000; **92**: 6–10.
7. White SM, Moppett IK, Griffiths R, et al. Secondary analysis of outcomes after 11,085 hip fracture operations from the prospective UK Anaesthesia Sprint Audit of Practice (ASAP-2). *Anaesthesia* 2016; **71**: 506–14.
8. Sell A, Olkkola KT, Jalonen J, Aantaa R. Minimum effective local anaesthetic dose of isobaric levobupivacaine and ropivacaine administered via a spinal catheter for hip replacement surgery. *British Journal of Anaesthesia* 2005; **94**: 239–42.
9. Kehlet H, Aasvang EK. Regional or general anesthesia for fast-track hip and knee replacement – what is the evidence? *F1000Research* 2015; **4**: 1449.
10. Aksoy M, Comez M, Ince I, Ahiskalioglu A, Misirlioglu M. Continuous spinal anaesthesia for hip fracture surgery in a high-risk patient. *Turkish Journal of Anaesthesiology and Reanimation* 2015; **43**: 55–7.

